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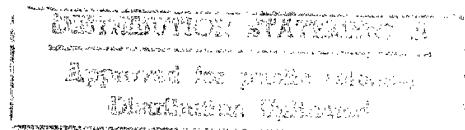
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USSR Report

PHYSICS AND MATHEMATICS

No. 80



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CRYSTALS AND SEMICONDUCTORS

SUPersonic DYNAMICS OF DOMAIN WALLS IN YTTRIUM ORTHOFERRITE

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian
Vol 35, No 9, 5 May 82 (manuscript received 23 Mar 82) pp 373-375

CHETKIN, M. V., GADETSKIY, S. N. and AKHUTKINA, A. I., Moscow State University
imeni M. V. Lomonosov

[Abstract] A study was made of the dynamics of domain walls in YFeO₃ at supersonic velocities. At such velocities the displacement of domain walls ceases to be one-dimensional, especially at a temperature near 100 K corresponding to maximum mobility. Tests were performed with 100 μm thick specimens cut perpendicularly to the optical axis. Light pulses of 6 ns duration for high-speed photography were obtained from oxazine dye pumped by an LGI-21 laser. Measurements in a magnetic field indicate that at magnetic field intensities above 60 Oe the displacement at velocities above 4000 m/s becomes two-dimensional. As the mobility of domain walls reaches 20,000 cm/(s·Oe), moreover, their motion becomes distinctly nonsteady. This evidence calls for refinement of the theory of domain wall and acoustic wave interaction, which so far has considered only one-dimensional motion of domain walls. Figures 3, references 7 Russian.
[185-2415]

DETECTION OF LONG-WAVE INFRARED RADIATION EMISSION BY HOT HOLES IN GERMANIUM IN CROSSED ELECTRIC AND MAGNETIC FIELDS

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian
Vol 35, No 9, 5 May 82 (manuscript received 1 Mar 82) pp 360-362

VOROB'YEV, L. Ye., OSOKIN, F. I., STAFEYEV, V. I. and TULUPENKO, V. N.,
Leningrad Polytechnic Institute imeni M. I. Kalinin

[Abstract] It has been demonstrated experimentally that strong scattering of hot holes by optical phonons in p-Ge in crossed electric and magnetic fields at low temperatures causes inversion of the distribution function of light holes relative to that of heavy holes, which makes possible emission and amplification of long-wave infrared radiation. A specimen of p-Ge with impurity concentration $n_p = 10^{15} \text{ cm}^{-3}$ was placed in an optical resonator formed by two mirrors with a reflection coefficient of 100% and 96-98% (exit mirror) respectively. A 50 μm

wide vacuum gap served as selector of longitudinal modes at wavelengths not shorter than 100 μ m. Radiation emission at 10 and 80 K temperatures was detected by a Ge<Ga> photoreceiver at 4.2 K with a set of filters (quartz, Teflon, black polyethylene). Spontaneous emission, occurring without a resonator, was not detected. The dependence of intensity of stimulated emission on both electric field intensity and magnetic field intensity was found to be characterized by a threshold corresponding to inversion of the hole distribution function, after which impurity scattering independent of the temperature becomes the principal mechanism. Reflection losses exceed by far diffraction losses at mirrors, and at relatively low hole concentrations it is easily possible to satisfy the conditions for emission of longer-wave ($\lambda > 200 \mu$ m) radiation. The authors thank I. B. Levinson for helpful comments. Figures 3, references 9: 7 Russian, 2 Western.
[185-2415]

CONVERSION AND MULTIPLICATION OF SIGNAL FREQUENCY IN ACOUSTIC-INJECTION TRANSISTOR

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 52, No 4, Apr 82
(manuscript received 23 Jun 81) pp 793-794

GULYAYEV, Yu. V., MANSFEL'D, G. D. and ORLOVA, G. A., Institutes of Radio Engineering and Electronics, USSR Academy of Sciences, Moscow

[Abstract] A new acoustoelectronic device, an acoustic-injection transistor, is considered for frequency conversion and multiplication. The operation of this device rests on the principle that the impedance of a semiconductor connected in series with a voltage source (frequency f_V) and load resistor is made to oscillate at the frequency of volume or surface acoustic waves (f_A) by the electron bunches accompanying these waves. The two frequencies add and subtract in the load current, in which two corresponding components can be detected. The feasibility of frequency conversion by means of such a device has been demonstrated theoretically on the basis of the relation between output and input voltages, also experimentally with an electroacoustic transducer exciting surface acoustic waves at 83.4 MHz in a Y-cut LiNbO₃ crystal on whose surface has been deposited a 2 μ m thick photosensitive CdS film containing resistive inter-digital transducer contact tabs and having a resonance frequency of 28 MHz. The voltage generator was tuned to the same frequency 28 MHz. Signals appeared across a 30 ohm load at frequencies 111.4 MHz ($f_A + f_V$), 56 MHz ($f_r + f_V$), and 55.4 MHz ($f_A - f_V$). A surface acoustic wave at frequency $f_r = 28$ MHz was generated by a periodic array of contact tabs, acting as an electroacoustic transducer shunted by the semiconductor film. The authors thank I. M. Kotelyanskiy, V. I. Krikunov and Ye. N. Mirgorodskaya for preparing the specimens, also S. V. Boritko for assisting with the measurements. Figures 2, references 3 Russian.
[186-2415]

STRUCTURAL ANOMALIES IN THIN COLUMBIUM AND TUNGSTEN FILMS PRODUCED IN DISCHARGE WITH OSCILLATING ELECTRONS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 52, No 4, Apr 82
(manuscript received 4 Oct 80, after final revision 15 Jan 81) pp 765-768

KONONKOVA, N. N., REYKRUDEL', E. M. and SMIRNITSKAYA, G. V., Moscow State University imeni M. V. Lomonosov

[Abstract] An experimental study was made of tungsten and columbium films produced by sputtering in a discharge with oscillating electrons. This method can yield high-quality films, inasmuch as they build up under low gas pressure with continuous electron or ion bombardment of both film and substrate. Polycrystalline bulk specimens were used as feed material, with an impurity content of 0.013% C + 0.02% O in the tungsten cathode and $10^{-5}\%$ total in the columbium cathode. Auger spectroscopy revealed the same impurity content in the films, with maximum concentration at the surface. Electron and x-ray diffraction analysis revealed a quasi-amorphous structure in tungsten films less than 100 Å thick and in columbium films less than 200 Å thick. Thicker films contained, in addition to their normal b.c.c. α -phase, also their anomalous c.p.h. β -phase as well as respective oxide (WO_3 , CbO_2) and carbide (W_2C , Cb_2C). Thicker films of both elements were found to have a fine-grain structure (50-150 Å), regardless of the conditions of film deposition, the grains being larger and increasing with film thickness in columbium. Up to 10,000 Å crystallites of the pure element or its oxide formed in the fine-grain structure of thicker tungsten films bombarded by electrons at a positive bias voltage (330 V) and in columbium films bombarded with electrons at a zero bias voltage (much lower electron flux intensity). Figures 4, references 5: 3 Russian, 2 Western.
[186-2415]

ELECTROACOUSTIC STORAGE OF SURFACE ACOUSTIC WAVES IN SYSTEM THAT INCLUDES $LiNbO_3$ AND EFFICIENT SECONDARY EMITTER FILM

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 10, 26 May 82 (manuscript received 16 Feb 82) pp 604-607

VOROSHEN', V. I. and CHIRKIN, N. M., Minsk Radio Engineering Institute

[Abstract] Electroacoustic storage is based on nonuniform redistribution of low-energy secondary electrons in piezoelectric fields of surface acoustic waves, and the current density of these secondary electrons determines the amplitude of output signals and the frequency band of the storage. The parameters can be improved by increasing the coefficient of secondary electron emission of the crystal's surface. The results are given of an experimental study of electro-acoustic storage of surface acoustic waves in $LiNbO_3$ YZ-cut crystals with films of an efficient secondary emitter, viz., magnesium fluoride. The MgF_2 film

was deposited layer by layer onto a 60 X 10 X 2 mm crystal placed in a vacuum chamber on a turntable at whose three fixed positions ion plasma cleaning, resistive vaporization and subjection to an electron gun, respectively, were performed. A quartz sensor served the purpose of monitoring the thickness of the film as it was sprayed. Surface acoustic waves were excited by means of interdigital transducers with split electrodes effectively operating at the first and third harmonics. Measurements were made simultaneously at two frequencies, 30 and 90 MHz, with identical configuration of crystal and gun and identical thicknesses of the deposited layer. Experimental curves are presented, illustrating the dependence of the amplitude of the reproduced signal on the total charge density of the record and reproduce electron beam. Seven experiments were conducted with MgF₂ films measuring 3, 8, 18, 52, 100, 260 and 500 nm thick. Curves are also presented for the crystal before deposition of the film. The experimental results demonstrate that it is not advisable to use films with the thickness of the sprayed film, h, much greater than the depth, s, for the discharge of secondary electrons from MgF₂ with specific energy of the primary beam. The optimum value of h for the frequency range of 30 to 90 MHz for MgF₂ is in the range of 20 to 50 nm. By depositing a film of efficient secondary emitter it is possible to increase approximately threefold the operating frequency of an electroacoustic storage. Figure 1, references 5: 4 Russian, 1 Western.
[198-8831]

ELECTRICITY AND MAGNETISM

UDC 537.533.335

FOCUSING OF FINE PARTICLES BY MEANS OF PLANE MAGNETIC FIELDS

Leningrad ZHURNAL TAKHNICHESKOY FIZIKI in Russian Vol 52, No 4, Apr 82
(manuscript received 27 Apr 81) pp 729-734

SHTEPA, N. I., Chernigov Pedagogical Institute imeni T. G. Shevchenko

[Abstract] The feasibility of focusing and transforming beams of fine ($10^{-1} - 10^{-4}$ cm) spherical magnetic particles in vacuum or in fluids (gas, liquid) by means of a constant plane magnetic field with planar symmetry is established on the basis of theoretical analysis of particle ballistics. A second-order homogeneous ordinary differential equation describing the trajectory of a particle in such a field is obtained, assuming that the magnetic field is quasi-uniform in the vicinity of a particle, that the flow of the fluid obeys Stokes' law, and that interaction between particles as well as any fluctuation effects are negligible. Calculations are continued for the two extreme cases of a magnetization vector: consisting only of the constant residual component independent of the magnetic field intensity, and consisting only of the induced component proportional to the magnetic field intensity or being equal to zero. Focusing and transformation of a particle beam moving parallel to the axis near the plane of symmetry of the magnetic field in a stream of fluid flowing at constant velocity is considered using a weak thin cylindrical magnetic lens. It is found that the beam shaping process can be controlled, within some range, by varying the magnetic field intensity and the stream velocity. A beam of ferromagnetic or paramagnetic particles expands, while a beam of diamagnetic particles contracts. Calculations for carbon steel, quartz, and ebonite particles in an air stream indicate that a weak magnetic lens is effective only for ferromagnetic particles. References 5 Russian.

[186-2415]

CONTROL OF TIME AND SPACE STRUCTURE OF HIGH-CURRENT ELECTRON BEAM

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 10,
26 May 82 (manuscript received 11 Mar 82) pp 614-616

AYRAPETOV, A. Sh. and KRASTELEV, Ye. G., Physics Institute imeni P. N. Lebedev,
USSR Academy of Sciences, Moscow

[Abstract] It is necessary to control the time and space characteristics of high-current electron beams in solving many problems associated with their use. A demonstration is given of the possibility of controlling these parameters on account of interaction of the beam's electrons with a specially formed reverse-current magnetic field, using as an example devices for modulating the beam's current and controlling the form of its cross section, respectively. Devices implementing both methods employ vacuum transport channels with dielectric walls so that the high-current electron beam is propagated without external confining fields and conditions are absent for the flow of reverse current in the space of the channel. The device implementing the current modulation method consists of a segment of a dielectric tube placed behind the anode grid of the electron gun, an electron collector, and a reverse-current conductor situated at one end of the channel and connecting the collector with the grounded anode grid. The beam injected into the channel is propagated along it until the electrons strike the collector, after which part of the reverse current begins to flow through the metal conductor. Under the influence of the magnetic field of this current the electrons are deflected from the axis and strike the channel's wall and the reverse current circuit is closed through the plasma near the wall. The force acting on the electrons changes sign and the beam returns to its original position and the cycle is repeated, resulting in transverse oscillations of the beam which in turn result in modulation of the current of electrons exiting from the opening in the collector. Oscillograms are presented for the beam current with electron energy of approximately 500 keV for a modulator with a cylindrical channel 34 mm in diameter and a conical channel with an exit opening 17 mm in diameter. Current modulation cycles of approximately 6 ns and 3 ns, respectively, were achieved. The respective percentage modulations were approximately 30 percent and approximately 100 percent. The form of the cross section of a high-current electron beam can be controlled without deflection of the beam from the channel's axis by means of a similar device in which the electron collector is connected to the electron gun's anode by means of several symmetrically arranged wires. The configuration of the reverse current's magnetic field is then equivalent to the field of a multipole magnet with a number of poles twice that of the number of wires. Camera obscura measurements were made of electron bremsstrahlung using a tantalum target 0.4 mm thick, with channel diameter of 51 mm, channel length of 100 mm, beam current of approximately 10 kA and electron energy of approximately 500-kV. Figures 2, references 2 Russian.

[198-8831]

FLUID DYNAMICS

UDC 533.6.011.72

SELF-ADJOINT SHOCK WAVE WITH STRONG EMISSION OF RADIATION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 264, No 2, May 82
(manuscript received 25 Jan 82) pp 338-341

KALININ, A. V. and STEPANOV, A. Ye., Institute of High Temperatures, USSR
Academy of Sciences, Moscow

[Abstract] The dynamics of a shock wave propagating through rarefied gas can, under certain conditions, be affected by radiation emission by the gas occurring not only behind the wave front. In the case of a shock wave generated by expansion of a hot laser plasma its dynamics will be affected in that the radiative cooling of the gas behind the front becomes comparable with the work of expansion. The self-adjoint equations describing the behavior of plane, cylindrical, and spherical shock waves with one-dimensional flow can be reduced to a Cauchy problem at the steady-state limit with appropriate boundary conditions. This problem has been solved numerically for density, pressure, and temperature distributions behind the wave front, assuming a zero radial pressure gradient. This assumption is not valid, however, inasmuch as the solution violates the law of mass conservation behind the wave front, where almost the entire gas mass concentrates inside a thin shell. References 9: 7 Russian, 2 Western.

[190-2415]

DYNAMICS OF IONIZING SHOCK WAVES DURING ADIABATIC GAS FLOW

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 82,
No 4, Apr 82 (manuscript received 8 Jun 81) pp 1104-1113

ZOREV, N. N., SKLIZKOV, G. V. and SHIKANOV, A. S., Institute of Physics imeni
P. N. Lebedev, USSR Academy of Sciences

[Abstract] In an experimental study of strong ionizing shock waves generated by laser beams, "free" propagation of such shock waves was tracked with "Kal'mar" 9-channel equipment and by superhigh-speed schlieren photography under conditions of adiabatic flow of deuterium gas at 1.5-20 torr pressures.

Targets in the stream, solid and hollow glass spheres 70-250 μ m in diameter, were heated by a high-power light pulse, to form a plasmatic corona with a dropping density profile and expanding into the ambient space at velocities of 10^7 - 10^8 cm/s. The results are evaluated theoretically in terms of the solution to the corresponding equation of motion with spherical symmetry, based on energy balance under conditions of both ionization and dissociation. It is found that the radius-time diagram depends on the total energy in the wave as well as on density, velocity and pressure distributions behind the wave front, rather than on changes in the adiabatic exponent. A correlation between theory and experiment is established on this basis and, with the error of wave radius determination reduced to minimum, the maximum error of wave energy determination is estimated at 8%. The authors thank I. V. Nemchinov and V. B. Rozanov for helpful comments. Figures 3, table 1, references 26: 16 Russian, 10 Western.

[181-2415]

ELECTRONIC RELAXATION MECHANISM BEHIND POWERFUL SHOCK WAVE FRONT

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 9, 12 May 82
(manuscript received 30 Nov 81) pp 523-527

PROSTNEV, A. S. and YUSHCHENKOVA, N. I., Institute of Chemical Physics, USSR Academy of Sciences, Moscow

[Abstract] An intense exothermic stage exists in relaxation behind the front of a shock wave; nonmonotonic distributions of parameters behind the front and curving and breakdown of the front are associated with this. In inert gases this stage is represented by dissociative recombination of molecular ions, superequilibrium concentrations of which form near the shock wave front in reactions with metastable particles. A demonstration is given here of the possibility of nonmonotonic distribution of parameters in the reaction zone caused by processes of generation of metastable particles in combination with the reactions mentioned. The relaxation zone behind the shock wave is characterized by high translational temperatures of heavy particles, T, and relatively low temperatures of electrons, T_e . Processes of collision of heavy particles result in an increase in the internal energy of the system, electrons colliding with excited atoms tap this energy and the system tends toward a certain quasi-steady state caused by temperature nonequilibrium. In the region where $T_e < T$, the electronic relaxation mechanism includes groups of the following elementary processes: origin of active particles; formation of particles with high reactivity and high internal energy content; collision activation and deactivation of particles with different internal energies; processes of conversion of internal energy into kinetic energy; process of generation (avalanche formation) of metastable particles; and processes of destruction of active particles. The mechanism is formulated for a model of energy states of atoms including atoms of argon in the ground, metastable and excited states. The existence of the process of avalanche formation of metastable particles is a distinctive feature of the kinetic scheme, and the role of this process grows with an increase in the energy of the shock wave. Deactivation of metastable particles takes

place in collision with electrons and because of the low value of T_e transitions of metastable atoms into the ground state and population of A^* levels are the most effective, since the activation energy is now high. A quasi-steady relationship is established between concentrations of charged particles, n^* , and electrons, n_e , since the time for the establishment of quasi-steady values of n^* is much shorter than the relaxation time. Curves are shown, illustrating the dependence on the Mach number of the frequency of oscillations of electron concentration and its ratio to the damping factor in the relaxation zone behind a shock wave in argon with various kinetic constants. With low Mach numbers oscillations do not originate because of the low rate of formation of metastable particles, and with very high Mach numbers oscillations are damped rapidly. Figure 1, references 6: 5 Russian, 1 Western.
[197-8831]

LASERS AND MASERS

UDC 535.37

CATHODOLUMINESCENCE OF CERTAIN SEMICONDUCTORS AND DEVELOPMENT OF LASER WITH ELECTRON-BEAM PUMPING

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 36, No 5, May 82
(manuscript received 21 Sep 81) pp 738-745

KURBATOV, L. N., DIROCHKA, A. I. and KOZINA, G. S.

[Abstract] Studies made pertaining to the mechanism and the spectrum of impurity-band cathodoluminescence of GaAs, polycrystalline A^2B^6 and laminar A^3B^6 , also ternary semiconductor compounds are reviewed from the standpoint of their impact on subsequent development of lasers with electron-beam pumping. Foremost among these materials are lead-tin chalcogenides and $GaSe_xTe_{1-x}$ solid solutions, monoclinic ($0 \leq x \leq 0.35$) or hexagonal ($0.6 \leq x \leq 1$). The spectrum covered so far includes ultraviolet 0.3-0.4 μm (ZnS, ZnO, $Ga_xAl_{1-x}N$), visible 0.4-0.7 μm (CdSe, CdSSE), near infrared 0.7-0.9 μm ($GaAs_{1-x}P_x$, $0 \leq x \leq 0.41$), near infrared 0.9-2.0 μm (InGaAs, GaAsSb, InGaAsP/InP, InGaAsSb/GaSb). Promising are InAsSb on $InAs_xSb_yP_{1-x-y}$ interlayer for intermediate infrared 3-5 μm and $Pb_{1-x}Sn_xTe$ ($0.05 \leq x \leq 0.2$) for intermediate infrared 8-14 μm . A further development will be materials for smooth wavelength regulation. Figures 4, references 22: 16 Russian, 6 Western.
[192-2415]

UDC 621.378.3

STABILIZED GAS-DISCHARGE LASER WITH EXTERNAL ABSORPTION CELL IN GAIN MODULATION MODE

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 36, No 5, May 82
(manuscript received 6 May 81) pp 722-727

MIRONOV, A. V. and PRIVALOV, V. Ye.

[Abstract] The effect of gain modulation on the frequency stability of a laser is examined in the case of frequency stabilization by means of an absorption cell. The radiation intensity is assumed to be modulated harmonically, through

modulation of the discharge current in the active medium, while simultaneously the radiation frequency is modulated by a harmonic signal and by a frequency deviation signal. An external absorption cell is then preferable for a ring laser with opposing waves. Automatic frequency stabilization of such a laser requires elimination of the frequency shift due to the second-harmonic signal produced by the nonlinearity of the absorption cell circuit. Figures 2, references 8: 6 Russian, 2 Western.

[192-2415]

UTILIZATION OF NONLINEAR PROCESSES FOR FORMING HIGH-CONTRAST SUBNANOSECOND LASER PULSES

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 82, No 4, Apr 82 (manuscript received 24 Sep 81) pp 1079-1090

KORMER, S. B., KOCHEMASOV, G. G., KULIKOV, S. M., NIKOLAYEV, Vik. D. and SUKHAREV, S. A.

[Abstract] An experimental study was made with regard to utilization of a nonlinear process, namely transient Mandel'shtam-Brillouin stimulated scattering, for forming short laser pulses with high energy and power contrasts in gas under high pressure. An iodine laser was used with "Iskra-4" equipment, including a master oscillator with Mandel'shtam-Brillouin mirror, a plasma or ionine shutter, four amplifiers, and optical decouplers preventing self-excitation in the amplifier stages. Concurrent steady Raman stimulated scattering was avoided by ensuring arise time sufficiently short to allow suppression of this competing process after the energy threshold of Mandel'shtam-Brillouin stimulated scattering has been reached. With the master oscillator specially modified by using a Kerr cell and adding two preamplifier stages, it was found feasible to shorten the duration of laser pulses obtained in an SF₆ (6 atm) + Xe (39 atm) mixture from 0.6 to 0.3 ns (at 50% level) while retaining 1.1 kJ energy in the pulse and maintaining the rise time within 0.17-0.2 ns at single-channel output.

Figures 12, references 36: 30 Russian, 6 Western.

[181-2415]

UDC 621.378.325

TRANSVERSE-EXCITATION ATMOSPHERIC PRESSURE CO₂ PULSE LASER WITH COMPOUND PRE-PHOTOIONIZATION AND HIGH INPUT ENERGY DENSITY

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 52, No 4, Apr 82 (manuscript received 5 Jun 81) pp 801-803

NGUYEN THO WIONG and PUZEWICZ, ZBIGNIEW, Institute of Quantum Electronics, Warsaw

[Abstract] A reliable CO₂ pulse laser is described that features pre-ionization by vacuum ultraviolet radiation from two sources. The main discharge occurs between two polished copper electrodes with a Chang profile. Pre-ionization

is effected by means of a modified Lamberton-Pearson device with two tungsten wires connected to a high-voltage source and a pair of corona discharge electrodes that increase the local electric field intensity and field emission current. The system also includes Teflon plates with metal foil on the outside surface connected to the cathode and lining both main electrodes, three capacitors (storing, peaking, limiting), and an air discharge gap. Stable and uniform discharge was experimentally generated in mixtures with a high content of molecular gases, the optimum one $\text{CO}_2:\text{N}_2:\text{He} = 1:1:4$ being capable of admitting an energy input of 400 J/(1·atm) with wires only, 700 J/(1·atm) with sliding surface discharge only, and 900-1000 J/(1·atm) with both photoionization sources. Various photoionizable organic compounds were tested, triethylamine and diethyl-aniline yielding the best electrical characteristics and the widest stability range. The resonator was formed by a spherical mirror with a gold-coated surface and a plate of high-purity germanium. Laser emission pulses of 3 J energy were obtained from this device, with an efficiency reaching 10%. Figures 2, references 12: 4 Russian, 8 Western.
[186-2415]

MOLECULAR PHYSICS

SCATTERING OF MOLECULAR IONS AND THEIR ATOMIC COMPONENTS BY METAL SURFACE

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 82,
No 4, Apr 82 (manuscript received 18 Nov 81) pp 1096-1103

YEVSTIGNEYEV, S. A., ZVONKOV, S. N. and CHICHEROV, V. M., Institute of Atomic
Energy imeni I. V. Kurchatov

[Abstract] An experimental study was done to compare the energy distributions of scattered particle fluxes coming from a metal target bombarded by various molecular ions and their atomic components. The equipment consisted of a main ion source for measurements, a separator magnet, an auxiliary ion source for surface cleaning, inside a scattering chamber made of stainless steel and pre-evacuated to residual pressure of $(1-2) \cdot 10^{-8}$ torr, also a particle detector, an electrostatic-type energy spectrum analyzer with power supply, and an XY-plotter. Rhodium, titanium, gold and copper targets were each bombarded separately with 20 keV N_2^+ , C^+ , O^+ , (energy of atomic ion made equal to its kinetic energy when part of corresponding molecular ion). The results indicate distinct differences between the various energy spectra attributable to peculiarities of scattering molecular ions, namely reflecting particles with energy higher and with energy lower than that of scattered corresponding atoms. The differences in absolute energy levels were found to be much less significant, however, an indication that scattering of individual atoms in a molecule is the governing process. In the case of molecular ions, moreover, there is a strong possibility of mutual scattering with attendant momentum transfer. The authors thank C. Yu. Luk'yanov for support and attentiveness, also O. B. Firsov and Yu. V. Martynenko for helpful discussions. Figures 8, references 2:
1 Russian, 1 Western.
[181-2415]

OPTICS AND SPECTROSCOPY

UDC 621.375.8

WAVEFRONT REVERSAL IN MOLECULAR MULTIPASSAGE AMPLIFIER

Minsk ZHURNAL PRIKLADNOY APEKTROSKOPII in Russian Vol 36, No 5, May 82
(manuscript received 14 May 81) pp 730-733

AVER'YANOV, N. Ye., BALOSHIN, Yu. A., DERNYATIN, A. I. and PAVLISHIN, I. V.

[Abstract] Wavefront reversal due to interaction of light and matter is analyzed on the basis of a numerical computer experiment with four-photon mixing in the active medium of a molecular multipassage transverse-excitation atmospheric-pressure CO₂-laser amplifier, taking into account nonlinearity due to partial saturation. The principal parameter determining the feasibility of wavefront reversal in such an amplifier is the amplitude or intensity reflection coefficient for the incident E₃ wave at the "phase coupled" mirror. The amplifier parameters determining the degree of saturation have been optimized for this experiment, with typical cavity length L = 1 m and intensities of both complex-conjugate photoionizing excitation waves I₁ = I₂ = 0.8·10⁶ W/cm². Figures 2, references 5: 3 Russian, 2 Western.

[192-2415]

PRODUCTION OF COLOR REFLECTION HOLOGRAMS USING BLEACHED PE-2 PHOTOGRAPHIC PLATES

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 10,
26 May 82 (manuscript received 10 Mar 82) pp 597-599

DENISYUK, Yu. N., ARTEM'YEV, S. V., ZAGORSKAYA, Z. A., KURSAKOVA, A. M.,
SHEVTSOV, M. K. and SHEDRUNOVA, T. V.

[Abstract] If a holographic image of an object is recorded on various layers of film by light of different wavelengths and these films are processed individually, it is possible to combine them so that the separate monochrome images of the object will merge into a single multicolor image. The results are given here of a study of the possibility of using for this purpose PE-2 photographic plates produced by Soviet industry. Bleaching was performed so that the silver forming the image is oxidized and is converted into the corresponding poorly soluble silver salt. This salt is characterized by its own

characteristic color, by transparency and by stability under the influence of light and has a refraction coefficient greater than that of the gelatin emulsion layer. In bleached holograms the refraction coefficient increases with an increase in the amount of bleached silver, resulting in improvement of the diffraction efficiency of holograms. A special processing method was developed for the purpose of achieving high diffraction efficiency for reflection holograms over the entire visible range of the spectrum when using PE-2 photographic plates. The plates are first hardened in SH-5 hardener for 5 min and are then washed in distilled water for 1 min and bleaching is performed for not less than 10 min in Phillips' bleaching agent, described in an earlier paper (1976) and consisting of 15 g of $\text{Fe}(\text{NO}_3)_3$, 3.3 g of potassium bromide, 2 g of glycerine, 50 ml of isopropyl alcohol and 50 ml of distilled water to prepare a stock solution. A 1:4 dilution in water is employed as a working solution. The plates are again washed in distilled water for 10 min and dried. All processing steps take place at 20° C. The processing method made it possible to achieve diffraction efficiency of up to 50 percent for wavelengths over the entire optical spectrum and shrinkage of the photographic emulsion was insignificant, equaling not greater than 3 to 4 nm. The shrinkage factor is important for proper color transmission. Individual images were recorded in the red (633 nm) and blue-green (530 and 476 nm) regions of the spectrum and both holograms were cemented together, emulsion to emulsion, with OK-72 optical cement. A good color image was produced by using the processing method described above. Figures 2, references 4: 2 Russian, 2 Western.

[198-8831]

WAVEFRONT REVERSING PLANE PARAMETRIC REFLECTOR

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 9, 12 May 82 (manuscript received 1 Mar 82) pp 554-559

BRYSEV, A. P., BUNKIN, N. F., VLASOV, D. V. and GERVITS, L. L., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] A simple physical interpretation is presented of a plane parametric wavefront reversing reflector, and a brief description is given of the first experiments with it. The parametric wavefront reversal mechanism caused by modulation over time of the Fresnel reflection factor is discussed. Essentially the wavefront reversal mechanism in a plane parametric reflector boils down to the following. If a wave with frequency ω and wave vector \vec{k} is incident at an angle of θ on a plane surface oscillating in phase in the direction of the normal at a frequency of 2ω , then the angle spectrum of reflected waves will contain a component that is reflected strictly in direction $-\vec{k}$. Experiments were conducted with an ordinary acoustic radiator as a parametric wavefront reversing reflector. Two connected plane-parallel piezoelectric plates measuring 75 X 5 X 0.5 mm made of TsTS-22 ceramic immersed in a polyethylene cell with a wall thickness of approximately 0.1 mm, transparent for sound waves, filled with C_5F_{12} , served as the wavefront reversing reflector. The reflector was placed at an angle of approximately 45° to the acoustic axis of the system. A pulse

generator for synchronizing the operation of the entire system, an rf pulse generator, a receiver (part of the YaKR ISSh-13M pulsed wideband radio spectrometer) and a G5-54 controlled-delay pulse generator were used with a double-frequency radio pulse generator, assembled from the ISSh-13M. A type S1-74 oscilloscope was used to observe and record the results and a piezoceramic transducer for radiating and receiving acoustic pulses. Collecting and diverging acoustic lenses and the irregular shape of the cell's entry window served as the phase plate. Radio pulses with frequency of 2 MHz are converted by the piezoceramic radiator into acoustic pulses which are propagated in a water tank in the direction toward the wavefront reversing reflector. After passing the phase plate, the acoustic pulses with distorted wavefront strike the surface of the reflector. Linear scattering of sound by the reflector is observed if the instant of transmitting a radio pulse of doubled frequency does not coincide with the arrival of an acoustic pulse at the reflector. If the instant of transmitting a "pumping" wavefront reversing radio pulse of doubled frequency coincides with the time of arrival at the reflector of an acoustic pulse, then reversal of the wavefront of the acoustic pulse takes place on the surface of the reflector oscillating at the doubled frequency. Figures 3, references 4: 3 Russian, 1 Western.

[197-8831]

CALCULATION OF SPEED OF RESPONSE OF STIMULATED BRILLOUIN SCATTERING MIRROR

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 9,
12 May 82 (manuscript received 18 Feb 82) pp 542-545

SIDOROVICH, V. G.

[Abstract] A theoretical estimate is made of the speed of response of a stimulated Brillouin scattering mirror when the exciting radiation consists of four light beams incoherent relative to one another with slight divergence. When using stimulated Brillouin scattering mirrors in multichannel laser systems the various channels can become mutually incoherent because of unsteady self-stresses of the light beams and because of pumping-induced changes of active element permittivity. The interaction of plane monochromatic components of the exciting and Stokes waves through the hypersonic arrays created by them in the scattering medium is discussed, and the possibility of the identity of arrays created by various pairs of interacting waves is taken into account. By this method it is possible to suggest a variant for arranging the exciting beams enabling the best speed of response of the stimulated Brillouin scattering mirror. The question of the maximum permissible width of the spectrum of incoherent exciting radiation at which wavefront reversal still occurs, i.e., of the speed of response of the stimulated Brillouin scattering mirror, has not been studied hitherto. Curves are given showing how increments of components of the Stokes wave depend on parameter Δ/Γ , where Γ represents the width of the spectral line of spontaneous scattering at intensity level 0.5. It is demonstrated that when $\Delta/\Gamma \gtrsim 0.15$ the total increment of the reversed mode is a unit less than

that of the unreversed mode so that wavefront reversal can be observed only with $\Delta/\tau < 0.1$. The graphs shown have physical meaning when $\Delta \gg 1/t_i$, where t_i is the duration of the exciting radiation pulse. Figure 1, references 6 Russian.

[197-8831]

INTERACTION OF ANGULAR COMPONENTS OF STOKES WAVE IN EXCITATION OF STIMULATED BRILLOUIN SCATTERING BY LIGHT BEAMS WITH PERIODIC SPACE STRUCTURE

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 9, 12 May 82 (manuscript received 15 Feb 82) pp 532-537

VLASOV, D. V., GARAYEV, R. A. and SIDOROVICH, V. G.

[Abstract] The results are given of an experimental and theoretical study of combined processes accompanying stimulated Brillouin scattering of light beams with a periodic space structure. The simplest case of interaction in a non-linear medium of two plane pumping waves and two Stokes waves is discussed. This process differs fundamentally from the case of a single plane pumping wave in that coherent scattering of each pumping component is possible in the overall hypersonic array created by both components in combination. This is evidenced by synchronism with the light of third-order nonlinear polarization components corresponding to scattering of pumping waves in the overall hypersonic array. The condition is derived for generation of a combined hypersonic array for two pumping waves and two Stokes waves. The case where the pumping and Stokes waves contain four plane components each with mutually inverted wave vectors is examined. When certain conditions are fulfilled synchronism of scattering of each of the pumping waves in the overall hypersound is made possible. It is shown that in the case of two pumping components rescattering in the overall hypersound tends to compensate the intensities of the Stokes waves inverted in relation to the pumping waves. For excitation of stimulated Brillouin scattering by pumping from four interphased angular components it is necessary to fulfill the threshold condition $9GL \approx 25$, where G represents the intensity increment corresponding to excitation of stimulated Brillouin scattering by one of the plane pumping components and L is the longitudinal dimension of the nonlinear medium. The theoretical conclusions were confirmed by an experimental study of the interaction of angular components of a Stokes wave in stimulated Brillouin scattering using a setup described in an earlier study (1982). In front of a cell with nitrobenzene was placed a glass plate reflecting part of the Stokes radiation onto a lens with focal length of 1 mm in whose focal plane was placed a camera. The experimental results confirm the theoretical conclusions. Figures 3, references 9 Russian.

[197-8831]

AMPLIFICATION OF 'TRAVELING' HOLOGRAMS IN $\text{Bi}_{12}\text{SiO}_{20}$ CRYSTALS

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 9,
12 May 82 (manuscript received 29 Jan 82) pp 527-531

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[Abstract] Crystals of the $\text{Bi}_{12}\text{SiO}_{20}$ type are highly sensitive to volume holographic recording because of the long average transfer distances of photo-induced electrons which are commensurate with or even substantially longer than the period of the recorded interference pattern, and this fact together with the long average drift length of electrons in an external field applied to a specimen results in a new specific mode for recording and optical erasure of holograms, making it possible to call these "traveling" holograms. When optical erasure is performed in the presence of an external field making possible a sufficiently high average value of the length of electron drift, the electron density maxima in the conduction band will correspond to the minima of the total field, and the recapture of electrons in deep traps results in a shift of the original array in the direction of the external field. The slowing of erasure in an external field makes it possible to increase the stationary amplitude of the hologram, but this is possible only with an optimum recording mode, when the interference pattern to be recorded moves in synchronism with the hologram. Thus, a mechanism exists for amplification of a hologram recorded by a traveling interference pattern. Amplification is caused by effective reduction of the rate of optical erasure of the hologram in a strong external field and is achieved with optimum synchronization of the interference pattern with the recorded hologram. This mechanism was tested in (110)-oriented specimens of $\text{Bi}_{12}\text{SiO}_{20}$ with their [001] axis perpendicular to the plane of incidence. Holograms were recorded by means of beams of an argon laser with wavelength of 0.51 micron linearly polarized in the plane of incidence and approximately of identical intensity, and reading was performed with an He-Ne laser. Low initial contrast of the pattern to be recorded was achieved by uniform illumination of the specimen with an incandescent lamp through a ZhZS-19 filter. A traveling interference pattern was created by moving one of the mirrors of the interferometer in a straight line. An experimental curve is given showing how the characteristic time for erasure of a hologram by means of the incoherent light of an incandescent lamp depends on the magnitude of the external field. A curve is also shown, illustrating the change in the stationary value of the diffraction efficiency of the array versus the rate of movement of the recorded interference pattern. Figures 2, references 4: 1 Russian, 3 Western.

[197-8831]

OPTOELECTRONICS

UDC 518.74:007.57

ALGORITHMIC DETERMINATION OF DELAY TIME IN DATA TRANSMISSION WITH CONFLICT SITUATIONS IN MULTIMODULAR HIERARCHICAL SYSTEMS

Kiev KIBERNETIKA in Russian No 2, Mar-Apr 82 (manuscript received 17 Nov 81)
pp 126-128

ZHUK, OSKAR VENIAMINOVICH, graduate student, Institute of Cybernetics, UkrSSR Academy of Sciences, Kiev

[Abstract] A multimodular hierarchical data processing system is considered consisting of functionally oriented modules and a commutation field, the latter composed of switching modules, with a fixed number of communication channels for "each to each" connection of all functional modules. Necessary and sufficient conditions for a conflict situation to arise are, respectively, at least one communication channel simultaneously common to different paths and two or more functional module "transmitters" simultaneously feeding at least one such channel. An algorithm is proposed for minimizing the total delay time in conflict situations through optimization of the sequence of communication channel switching. This is demonstrated on a simple three-level hierarchical scan system. The author thanks Yu. L. Ivas'kiv for suggesting this topic of study.

Figures 2, references 3 Russian.

[182-2415]

THEORY OF NONLINEAR OPTICAL FREQUENCY CONVERSION IN CHOLESTERIC LIQUID CRYSTALS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 82, No 4, Apr 82 (manuscript received 25 Nov 81) pp 1159-1169

BELYAKOV, V. A. and SHIPOV, N. V., Scientific Research Institute of Radio Technical Measurements

[Abstract] Nonlinear optical frequency conversion in a cholesteric liquid crystal is analyzed, assuming first that the pumping light wave propagates along the crystal axis. Considered as a specific example is generation of the third harmonic in the approximation of a fixed pumping wave. The corresponding boundary-value problem is solved, taking into account synchronism under conditions

of diffraction. The maximum conversion efficiency is calculated on this basis and conditions for increasing the efficiency by means of selective reflection are established, also the necessary constraints on pumping wave and material parameters (period of crystal structure, thickness, anisotropy of permittivity). The analysis is extended to oblique incidence of the pumping light wave. The authors thank V. Ye. Dmitrenko for discussing the study. Figures 3, references 13: 9 Russian, 4 Western.

[181-2415]

COMPARATOR LOGIC USING INTEGRATED-OPTICS INTERFEROMETER

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 52, No 4, Apr 82
(manuscript received 9 Apr 81) pp 775-777

VOYTENKO, I. G. and RED'KO, V. P., Mogilev Department, Institute of Physics, BSSR Academy of Sciences

[Abstract] An interferometer-type modulator is considered as a device for use in analog processing of data, specifically for comparing pulse signals of different amplitudes and durations. It consists of a stripline waveguide split in the middle into two identical straight channels by a 3-dB divider. The phase of a light wave in each branch is changed by application of an electric field. The merging waves interfere in accordance with their phase difference. The modulation efficiency, ratio of light intensities at the output with and without control voltage respectively, depends on the magnitude of the latter. The device can operate as a comparator of parallel codes. It was tested in comparing two sequences of square pulses, coming from different courses, with an avalanche photodiode serving as receiver. Pulses of equal amplitudes in both channel branches produced the maximum light intensity at the output, corresponding to zero phase difference and taken as logical "1". Pulses of unequal amplitudes produced an output signal proportional to the amplitude difference, any light intensity lower than maximum was taken as logical "0". Pulses of unequal amplitudes and durations produced a step signal at the output, its height proportional to the amplitude difference and its width proportional to the duration difference. The modulator thus can perform the logical operation $Z = XY + \bar{X}\bar{Y}$, equivalence of two logical variables X and Y. The output signal is $Z = 1$ only when both input variables have the same value. Figures 2, table 1, references 3 Western.

[186-2415]

UDC 532.783

WAVEFRONT REVERSAL OF LIGHT IN NEMATIC LIQUID CRYSTAL NEAR LIGHT-INDUCED
FREDERICKS TRANSITION

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 52, No 4, Apr 82
(manuscript received 30 Mar 81) pp 769-770

TABIRYAN, N. V. and CHILINGARYAN, Yu. S., Yerevan State University

[Abstract] The orientational optical nonlinearity of a nematic liquid crystal near the light-induced Fredericks transition is analyzed, assuming a light beam wider than the crystal cell, on the basis of the variational equation describing the equilibrium distribution of the director field over the crystal volume. This equation has been derived for a light wave linearly polarized along the x-axis and normally incident along the z-axis on the plates of a homeotropically oriented crystal cell. Analysis of the solution to this equation reveals an earlier predicted hysteresis of the Fredericks transition in crystals with $\alpha < 0$. The feasibility of wavefront reversal for low-power radiation is established for nematic liquid crystals with $\alpha > 0$. The authors thank N. F. Pilipetskiy and O. V. Garibyan for discussing the experimental aspects of the problem.
References 11: 10 Russian, 1 Western.

[186-2415]

UDC 537.533.3

DEFLECTION AND FOCUSING OF CHARGED PARTICLE BEAMS IN TRANSAXIAL ELECTROSTATIC
SYSTEMS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 52, No 4, Apr 82
(manuscript received 11 May 81) pp 735-739

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[Abstract] Electron-optical properties of transaxial electrostatic systems are revealed which make such systems suitable as dispersers or deflectors of charged particle beams as well as for forming a dispersionless image of such a beam. The analysis of beam ballistics, on the basis of Grinberg's theory of focusing, is confined to nonrelativistic beams whose axial trajectory lies in a plane and to electric fields which do not vary along one of the coordinates. With the source in a certain position, second-order focusing in the direction of dispersion is always possible. The image, generally a line, can be reduced to a point with the proper voltage across the electrodes. Figures 3, references 3 Russian.

[186-2415]

TRANSMISSION OF SPATIALLY NONHOMOGENEOUS IMAGES WITH AID OF OPTOELECTRIC MODULATORS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 52, No 4, Apr 82,
 (manuscript received 21 Sep 80, after final revision 10 Feb 81) pp 695-702

POKATILOV, Ye. P., FOMIN, V. M., VORONOVA, K. A. and RAPOPORT, B. I.

[Abstract] Optoelectric modulators are considered for transmission of spatially nonhomogeneous images. A "Fototitus" modulator consists of a semiconductor (photoreceiver) layer and an optoelectric layer stacked together, the photoelectric effect producing charge carriers in the semiconductor so that its conductivity becomes space modulated. The evolution of the resulting potential distribution in such a device is analyzed on the basis of the quasi-electrostatic field equations $\text{curl } E = 0$ and $\text{div}(\epsilon E) = (e/\epsilon_0)(p-n)$ for each layer. Taken into account are the rates of pair formation by absorbed light, intrinsic pair formation, electron and hole entrapment, and recombination. The permittivity tensor in each layer is assumed to be uniaxial. An equation is derived on this basis for the voltage across the optoelectric layer with relaxation control (Maxwell relaxation time much shorter than drift time, diffusion time and characteristic recombination time) or field control of carrier concentration, for quasi-neutrality of the semiconductor layer. The solution to this equation, obtained by Fourier transformation, describes how the voltage spectrum in space evolves as a function of time. Calculations are shown for the amplitudes of the first three components (fundamental first and second harmonics) over a period of 20 s. The authors thank N. S. Churchuk for performing the numerical computations. Figure 1, references 5: 3 Russian, 2 Western.
 [186-2415]

TELEVISION OPTICAL PROCESSOR BASED ON CHARGE-COUPLED DEVICE PHOTODETECTORS

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 9,
 12 May 82 (manuscript received 4 Jan 82) pp 521-523

GAVRILOV, G. A., GUREVICH, S. B. and SOTNIKOVA, G. Yu., Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] The results are given of a study of the possibility of creating television optical image processing equipment based on charge-coupled device photodetectors. A diagram is presented of a television optical processor for filtering images with a transfer characteristic formed by the two-aperture synthesis method, whereby two filtered images are produced and they are then subtracted. The transparency is placed between frosted glass and a beam splitter and is illuminated by the light of a pulsed source. An image of the slits in the CCD photodetector is formed in optical channels with different transfer characteristics, the image signals are subtracted in an ordinary differential

amplifier, and the difference signal is observed on a video monitor and on an oscilloscope. A special circuit is employed to control the operation of matrices and to synchronize them with the pulsed light source. The results are given of 2-dimensional high-frequency filtering of an image in incoherent light, whereby the image, i.e., a figured slit, was defocused in one of the channels. A photograph is presented of the outlined image of the slit along with an oscilloscope of the television signal line. It is concluded that it is feasible to use CCD photodetectors in television optical image processing systems even at the present time. The instrument used in the experiment contained 256 X 288 elements and two horizontal registers for input/output of information. Pulsed illumination of the subject makes it possible to double the number of resolvable elements in the image as compared with the ordinary continuous illumination mode requiring division of the light-sensitive surface of the matrix into charge accumulation and storage sections. Pulsed illumination results in a reduction in image defects associated with dark current inhomogeneity. Figures 2, references 3: 2 Russian, 1 Western.

[197-8831]

PLASMA PHYSICS

UDC 533.9.082

USE OF VACUUM ULTRAVIOLET RADIATION FOR STUDY OF FOIL HEATING BY FOCUSED ELECTRON BEAM

Moscow FIZIKA PLAZMY in Russian Vol 8, No 2, Mar-Apr 82 (manuscript received 28 Jul 80) pp 415-421

BABYKIN, M. V., BAYGARIN, K. A., BARTOV, A. V., GORBULIN, Yu. M., DAN'KO, S. A., KALININ, Yu. G., MALKOV, V. N. and SKORYUPIN, V. A., Institute of Atomic Energy imeni I. V. Kurchatov

[Abstract] In a thin foil absorbing a high-current (10^7 A/cm^2) high-power ($5 \cdot 10^{10} - 5 \cdot 10^{11} \text{ W}$) electron beam there forms a plasma of high concentration with a temperature of 30-50 eV which emits radiation predominantly in the vacuum ultraviolet range (10-1000 Å). The intensity of this radiation was measured in experimental studies with vacuum diodes, open and through filters. The diodes specially built for this purpose have aluminum cathodes. Both electrodes are flat so as to ensure optimum dynamic and transient characteristics. The minimum interelectrode gap is 0.3 mm corresponding, at a voltage of 2 kV, to a saturation space-charge current of 200 A/cm^2 and a linear dependence of diode current on radiation flux up to 10^5 W/cm^2 . Thin films of nitrocellulose are used as filters. The performance characteristics of such a diode, and correspondingly the results of measurements, are evaluated on the basis of power laws with empirical coefficients and exponents describing the dependence of diode current on source temperature and the relation between radiation power and current signals from two diodes (one with and one without filter). A deflecting magnet behind the foil prevents beam electrons from entering the vacuum diodes. The temperature distribution over the foil surface has been determined from x-ray densitograms and checked against photographs of the interelectrode gap in the beam generating diode, to correct for the effect of scattered foil material. Tests were performed using these vacuum diodes in NPR-2M and "Angara-1" instruments, with the S-60 synchrotron (Institute of Physics USSR Academy of Sciences) and a Planck etalon as radiation sources. The authors thank L. I. Rudakov for helpful discussions, also V. I. Kvochke and S. A. Anevskiy at the All-Union Scientific Research Institute of Optical Physical Measurements, M. N. Yakimenko and the entire staff of the High-Energy Electronics Laboratory at the Institute of Physics USSR Academy of Sciences. Figures 7; references 9: 8 Russian, 1 Western.

[189-2415]

UDC 533.951

NUMERICAL ANALYSIS OF MOTION OF PLASMA ABSORBING LIGHT AT FRONT OF SHOCK WAVE

Moscow FIZIKA PLAZMY in Russian Vol 8, No 2, Mar-Apr 82 (manuscript received 5 May 80, after correction 23 Mar 81) pp 262-268

BAKHRAKH, S. M., KAYNOV, V. Yu., KORMER, S. B., URLIN, V. D., SHANIN, A. A. and YANILKIN, Yu. V.

[Abstract] The two-dimensional transient problem of plasma motion due to release of laser energy has been solved numerically for the case where the front of the luminous detonation wave propagates quasi-steadily from a plane target. The wave front was assumed to be of negligible thickness so that heat conduction and existence of a two-temperature state could be disregarded. Calculations were made for light at the $1.06 \mu\text{m}$ wavelength in a medium of molecular nitrogen, taking into account dissociation and single ionization but disregarding the presence of molecular ions. The corresponding system of four equations of state, energy absorption, and plasma dynamics were solved numerically by splitting it on each computation step for evaluation first the gas dynamics and then the change of energy due to absorption of laser radiation. The results reveal the two-dimensional evolution of a plasma jet and the distribution of thermodynamic parameters, pressure and temperature, over its volume. The results differ from those based on the approximate quasi-one-dimensional model. Figures 5, references 19: 17 Russian, 2 Western.

[189-2415]

UDC 537.5

NEW TYPE OF IONIZATION WAVE AND MECHANISM OF POLARIZATION SELF-ACCELERATION OF ELECTRONS IN GAS DISCHARGES UNDER HIGH OVERVOLTAGE

Moscow DOKLADY AKADEMII NUAK SSSR in Russian Vol 263, No 1, Mar 82 (manuscript received 2 Oct 81) pp 76-79

BABICH, L. P.

[Abstract] It is demonstrated that in gas discharged under sufficiently high overvoltage the self-consistent development of ionization and acceleration processes results in the appearance of a new type of ionization wave propagated not only at speeds of $v_f \gg v_{(E_f)}$, where $v_{(E_f)}$ is the rate of drift of frontal electrons, but also of $v_f > c \sqrt{1 - [mc^2/(mc^2 + eU_0)]^2}$. Avalanche chains are formed in the "reaction zone," all of whose links develop almost simultaneously and this makes possible synchronization of the motion of the field wave and of accelerated electrons, which results in self-acceleration, characterized by a resonance polarization acceleration mechanism. In nanosecond gas discharges under considerable overvoltage self-acceleration is responsible for the generation of high-energy electron streams at the front of a streamer. The physical fundamentals of the resonance mechanism, sustained over time, are discussed. The ionization wavelength, λ , represents the dimension of the "reaction zone"

within which the ionization of atoms, polarization of the medium and acceleration of electrons take place. The simultaneous development along this wavelength of a great number of electron avalanches synchronizes the motion of accelerating electrons, the ionization wave and wave of the amplified field. The field wave and electrons accelerated in it appear to be linked by avalanche chains, as it were. Electron avalanches develop with sufficiently high E_f/P , where E_f represents the amplified field and P represents the pressure. The conclusions arrived at are based on the fact that under sufficiently high overvoltage, $\Delta U/U_s$, the classical streamer discharge mechanism is replaced by a mechanism in which the decisive role is played by the phenomenon of the "runaway" of electrons in the electric field. The results of Soviet studies (1974-1978) are regarded as the first observations of and research on the effect of self-acceleration of charged particles in gas discharges. References 15: 10 Russian, 5 Western.

[196-8831]

PROPAGATION OF SHOCK WAVES IN DECAYING PLASMA

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 9, 12 May 82 (manuscript received 24 Feb 82) pp 551-554

KLIMOV, A. I., KOBLOV, A. N., MISHIN, G. I., SEROV, Yu. L., KHODATAYEV, K. V. and YAVOR, I. P., Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] The results are given of a study of the passage of a shock wave through the decaying plasma of a glow discharge at instants following its quenching. The experimental apparatus used included, for the purpose of quenching the glow discharge, a circuit for shunting the interelectrode gap, assembled from a TGI-500/16 thyratron and triggered with short delays by means of a signal from a delayed pulse generator. The generator was synchronized by means of the signal triggering the thyratron, which in turn controls an electric discharge shock tube. A reversed switching circuit was used for the purpose of producing delays longer than the time for the shock wave to travel the distance from the shock tube to one of the electrodes. The voltage between the two electrodes after quenching of the discharge was not greater than 1 V. The rate of propagation of the shock wave was determined with accuracy of approximately 5 percent from the time it took for the wave to reach a piezoelectric transducer and from the known distance of 6 cm between the two electrodes of the discharge gap. The intensity of radiation from the discharge and its change after cutoff of the current were recorded by means of a photomultiplier tube. Experiments were conducted in the plasma of the air at various current densities and pressures in the chamber, and a series of oscilloscopes was obtained, of signals from the piezoelectric transducer with various delay times between the moment of cutoff of the current and entry of the shock wave into the plasma. The results demonstrate that the speed of the shock wave in the decaying plasma depends on the delay time, that with an increase in the delay time from 0 to about 1 s the amplitude of the shock wave in the plasma increases uniformly, that the width of the shock compression zone is reduced with an increase in delay time, and that

when the delay time is greater than 10^{-3} s the curvature of the shock wavefront increases. Under the conditions of the given experiments the energy in the shock-compressed decaying plasma is greater than the energy of compression in propagation of the shock wave in air. This confirms the hypothesis that the energy accumulated in internal degrees of freedom of particles in the glow discharge is released behind the shock wavefront. Figures 3, references 2 Russian.

[197-8831]

ACCELERATION OF SLOW LIGHT-BURNING WAVES

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 8, No 9, 12 May 82 (manuscript received 1 Feb 82) pp 537-541

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[Abstract] A brief survey is presented of studies relating to acceleration of slow light-burning waves. These waves have been observed when propagated toward the radiation of a neodymium laser after they had been initiated by an electric discharge or breakdown from an auxiliary laser. Under atmospheric pressure with a laser beam of small diameter and formation of a plasma the dominant mechanism in propagation of the laser spark is molecular and electronic heat conduction, and with laser beam dimensions on the order of 10 to 30 cm only a small part of the laser radiation is absorbed in the plasma, but with dimensions on the order of 1 cm radiant transfer of energy begins to play an important role. Theoretical and experimental studies have been made of fast light-burning waves propagated from an obstacle. Then expansion of the plasma generates strong shock waves and the pressure is far greater than atmospheric, resulting in great optical thickness of the plasma layer. The laser radiation is completely absorbed in the plasma and since the thermal radiant flux in it is considerable the radiation mechanism for propagation of the plasma front is the dominant one. An important role in initiation of fast waves is played by vaporization of the obstacle. Under sufficiently high pressure the origin of a plasma in the vapors enables strong absorption of the laser radiation. These waves can also originate with special initiation of the plasma. If the plasma formed as the result of breakdown or electric discharge is able to expand to atmospheric pressure by the start of the main pulse, while maintaining a sufficiently high temperature, a fast absorption wave can originate from a slow one. A simple model of this phenomenon is presented by solving an equation for the energy of an expanding slightly absorbing plane layer of plasma. The plane unsteady radiation gas-dynamic problem is solved taking into account in detail the spectral composition of the radiation. For this calculation the method of averaging radiation transfer equations was used, along with detailed tables of the optical properties of burning air. The heat conduction mechanism was taken into account in addition. Tables of molecular and electronic heat conduction coefficients were employed. It was assumed that at the initial moment of time in the air under atmospheric pressure a plane layer forms, 1 cm thick, with the required energy for the

initiating blast equaling about 5 J/cm^2 . The evolution of this layer is discussed under the effect of radiation of 1 eV with flux density of 1 MW/cm^2 . The initial optical thickness of the layer was approximately 0.01. Curves are shown for distribution of the temperature over the mass of the layer and over its thickness at various moments of time, and for distribution of laser radiation flux and of the "internal" heat flux of the plasma's radiation over the thickness of the layer. The optical thickness of the layer increased exponentially with a critical energy of about 150 J/cm^2 and at the end of 150 microseconds the velocity of the plasma boundary increased from 20-30 m/s to 200 m/s, resulting in an increase in pressure as compared with atmospheric, an increase in optical thickness, great acceleration of the wavefront and transition of the slow light-burning wave into a fast one. Figures 2, references 17: 14 Russian, 3 Western. [197-8831]

SUPERCONDUCTIVITY

PECULIARITIES OF NONHOMOGENEOUS CURRENT STATE IN WIDE SUPERCONDUCTOR FILMS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 82, No 4, Apr 82 (manuscript received 7 Aug 81) pp 1262-1266

D'YACHENKO, A. I., TARENKOV, V. Yu. and STUPAKOV, V. V., Donetsk Physico-Technical Institute, UkrSSR Academy of Sciences

[Abstract] Sandwich structures consisting of an SiO_2 film ($1 \cdot 10^{-6}$ cm thick) between two granular aluminum films (lower film $3 \cdot 10^{-6}$ cm thick and 0.3 cm wide, upper film $6 \cdot 10^{-6}$ cm thick and 0.1 cm wide) were studied in a superconductivity experiment, after having been deposited on glass substrates in an oxygen atmosphere under a pressure of 10^{-4} torr. Their current-voltage characteristics were measured in a cryostat at a temperature of $(0.7-0.8)T_c$ (superconducting transition temperature of aluminum $T_c = 1.8-1.9$ K, coherence length $\lambda = 5 \cdot 10^{-6}$ cm, Ginzburg-Landau parameter $\xi = 8-10$), shielded from external magnetic fields. The peculiar shape of the current-voltage curve, with a series of widening steps, is analyzed on the basis of the superconducting d.c. transformer model and the equations of motion for an eddy-current structure. It is attributed to the nonhomogeneous state in wide films with a large number of eddy strings which drag the signal. The authors thank V. M. Svistunov for formulating the problem and discussing the results. Figures 2, references 10: 6 Russian, 4 Western.

[181-2415]

MATHEMATICS

UDC 519.21

LAW OF LARGE NUMBERS FOR RANDOM VECTORS WITH VALUES OF ELEMENTS IN
 l_p ($1 \leq p < \infty$)

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: MATEMATIKA, MEKHANIKA, ASTRONOMIYA
in Russian No 7, Issue 2, Apr 82 (manuscript received 26 May 81) pp 111-115

SKOVORODA, B. F.

[Abstract] The law of large numbers is applied to a quasi-stationary sequence and a quasi-multiplicative sequence of random vectors. Two convergence theorems are proved, each with the aid of a lemma, for each kind of sequences of such vectors with values of elements in l_p ($1 \leq p < \infty$), $\alpha = \min \{1; p/2\}$ and then $\beta = \max \{1; 2(p-1)/p\}$. The first pair of these theorems generalizes Serfling's B and β theorems for quasi-stationary sequences. References 5: 2 Russian, 3 Western.
[188-2415]

UDC 517.5

TREND OF INCREASE OF LEBESGUE CONSTANTS IN POLYHEDRAL FOURIER SUMS

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: MATEMATIKA, MEKHANIKA,
ASTRONOMIYA in Russian No 7, Issue 2, Apr 82 (manuscript received 31 Mar 81)
pp 110-111

PODKORYTOV, A. N.

[Abstract] The rate of increase of Lebesgue constants (norms of operators) in partial sums of multiple Fourier series is estimated on the basis of a theorem applicable to any polyhedral representation. The theorem, proved with the aid of a lemma pertaining to a simplex, demonstrates that the Lebesgue constants increase as the power of the logarithm in the upper estimate for a cube according to E. S. Belinskiy. References 6 Russian.
[188-2415]

DYNAMIC GAMES WITH INFINITE NUMBER OF PLAYERS: FUNDAMENTAL CONCEPTS

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: MATEMATIKA, MEKHANIKA,
ASTRONOMIYA in Russian No 7, Issue 2, Apr 82 (manuscript received 3 Sep 81)
pp 69-75

PETROSYAN, L. A. and ULANOV, V. A.

[Abstract] Fundamental concepts are developed for a dynamic game with a continuum of players. The set of players is identified with a segment $I = [0,1]$ on which is given a nonatomic probabilistic measure. The game dynamics can be specified in terms of a system which, with the initial conditions fixed, in turn defines a semidynamic system. Analysis of such a game is facilitated by using the σ -algebra of Borel sets on segment I. With the payoffs assumed to be transferable, the characteristic function is constructed for a cooperative game and the payoff functional for the first (maximizing) player is determined in the corresponding set. These concepts are then applied to two games where the union of piecewise-intersecting segments represents the first player so that the characteristic function can also be determined in M-algebra. The results of both determinations are compared on the basis of two theorems, and the characteristic function is found to have the property of superadditivity. Next are considered games which involve payoff sharing, where none of the players alone can affect the outcome so that sufficiently large coalitions must be taken into account. Several definitions are added and two theorems are proved pertaining to existence and stability of the share function, the set of additive game kernel functions, and the conditionally optimum trajectory. References 4 Russian.
[188-2415]

ANALYSIS OF STATIONARY SEMI-MARKOV PROCESSES BY METHOD OF FICTITIOUS STATES

Kiev KIBERNETIKA in Russian No 2, Mar-Apr 82 (manuscript received 12 Oct 79)
pp 91-94

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[Abstract] Stationary ergodic semi-Markov processes, which occur in queuing systems, are analyzed by a decomposition method that involves fictitiously increasing the period of the embedded Markov chain. The method is based on two concepts: simple path from one state to an adjacent one and minimum normal vicinity of a state. It is validated by a theorem pertaining to equality of stationary probability distributions of two processes, original and expanded ones, and to similarity of paths on two corresponding graphs. It is demonstrated on a queuing network with exponential distribution of waiting time, simulating a two-loop computer network. Figures 3, references 6: 5 Russian, 1 Western.
[182-2415]

PURSUIT BY SIMPLE MOTION WITH TWO KINDS OF CONSTRAINTS ON CONTROL

Kiev KIBERNETIKA in Russian No 2, Mar-Apr 82 (manuscript received 1 Nov 79)
pp 80-84

BARDADYM, TAMARA ALEKSEYEVNA, candidate of physico-mathematical sciences,
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[Abstract] Analysis of differential games is extended to a game with simple motion where the controls satisfy both geometrical and integral constraints. Two theorems and a corollary are proved, with the aid of three lemmas pertaining to discontinuity and termination time. The pursuit game

$$\begin{array}{ll} \dot{x}=u & x \in \mathbb{R}^n \\ \dot{y}=v & y \in \mathbb{R}^n \\ M=\{x, y : x=y\} \end{array}$$

with constraints

$$\begin{aligned} \|u\| \leq \alpha, \quad & \int_0^\infty \|u(\tau)\|^2 d\tau \leq \mu^2 \\ \|v\| \leq \beta, \quad & \int_0^\infty \|v(\tau)\|^2 d\tau \leq \nu^2 \end{aligned}$$

is considered as an example. The author thanks B. N. Bshenichnyy, N. Z. Schor, G. Ts. Chikriy and M. S. Nikol'skiy for attentiveness and helpful comments.

[182-2415]

APPROXIMATE-SOLUTION ALGORITHM FOR SYSTEMS OF NONLINEAR EQUATIONS

Kiev KIBERNETIKA in Russian No 2, Mar-Apr 82 (manuscript received 21 Mar 80)
pp 74-79

BABICH, MIKHAIL DANILOVICH, candidate of physico-mathematical sciences, senior scientist, and SHEVCHUK, LUDMILA BORISOVNA, senior engineer, both of the Institute of Cybernetics, UkrSSR Academy of Sciences, Kiev

[Abstract] One of the most difficult problems in solving nonlinear equations and systems of such equations on a computer is finding the initial approximation from which iterations will lead to an acceptable result. Here an algorithm is shown which within a prescribed region separates all isolated solutions to a system of nonlinear algebraic and transcendental equations, finds the initial approximations for subsequent iterations and then approximates all separate solutions with any desired accuracy attainable by the computer. This ϵ_s -algorithm is based on the method of ϵ -grids, applicable to nonlinear operator equations with a completely continuous operator in a convex compact space, and involves transforming the sequence of ϵ -grids in this compact space while

satisfying certain conditions. The algorithm is demonstrated on the general system of n equations $u_n = f_n(u_1, u_2, \dots, u_n)$. Its basic steps are analysis and transformation of equations, construction of grids in an n -dimensional cube R^n selected as the compact space, sampling of points in these grids, forming and determining resolvent sequences. A theorem is stated and proved which validates the final step. The algorithm has been programmed in FORTRAN for a BESM-6 computer, the latter usually requiring an external storage for fast increasing data arrays. The algorithm was tested experimentally on the system of equations

$$u_1 = \frac{3}{4}u_1 + \frac{1}{4}\sin 8u$$

$$u_2 = u_2 - u_1 u_2 + \frac{1}{8}$$

and on the equation

$$u(x) = \frac{1}{2} \int_0^1 \sin xy [u(y)]^2 dy + 1$$

Table 1, references 14 Russian.
[182-2415]

UDC 518.9

APPROXIMATE SOLUTION OF PURSUIT-EVASION PROBLEMS IN DIFFERENTIAL GAMES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 263, No 1, Mar 82
(manuscript received 2 Sep 81) pp 30-34

OSTAPENKO, V. V., Institute of Cybernetics, Ukrainian SSR Academy of Sciences, Kiev

[Abstract] As an example of problems relating to approximation in differential games, an approach is suggested that makes it possible to approximate in Hausdorff metrics the value of the primary operator by a set permitting a more structured construction, and making it possible in a number of cases to estimate this proximity. The differential games discussed are described by the equation $\dot{z} = f(z, u, v)$, where $z \in Z$, $u \in U$, $v \in V$, and Z is a finite-dimensional Euclidian space with a dot product of $\langle \cdot, \cdot \rangle$ and U and V are compact sets in finite-dimensional Euclidian spaces. The terminal set, M , and the set of phase constraints, N , are assumed to be compact and M is contained in N . Relative to function f and sets U and V it is assumed that $f(z, u, v)$ is continuous relative to the set of variables and doubly continuously differentiable in terms of z ; that a constant C exists such that for all $z \in Z$, $u \in U$ and $v \in V$, $|\langle z, f(z, u, v) \rangle| \leq C(1 + \|z\|)$; and that set $f(z, U, v)$ is convex for all $z \in Z$ and $v \in V$. The permissible controls of the players, P (pursuer) and E (evader), represent measurable functions $u(t)$ and $v(t)$ with values in U and V respectively. Pursuit-evasion games with a fixed and unfixed time for completion of the game are described fully by primary operators $\tilde{T}_{N,t}(M)$ and $\tilde{P}_{N,t}(M)$, which place in correspondence with set M the set of all points from which player P can, by playing in ε -strategies, develop a path to set M not

later than during time t and precisely at instant of time t . The path does not go beyond the limits of set N . The conditions are found under which set $\tilde{T}_{N,t}(M)$ ($\tilde{P}_{N,t}(M)$) can be approximated by set $\theta_{N,h}^n(M)$ ($\pi_{N,h}^n(M)$), where $nh = t$ and θ^n represents the n -th iteration of operator θ , and an estimate is made of their proximity. A description is given of strategies with which the opponents can play the game in order to complete it with a certain error. It is assumed that $h > 0$. References 7 Russian.

[196-8831]

CSO: 1862

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